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To: "wtc@nist.gov" <wtc@nist.gov>
Subject: FW: Comments on the 7 WTC report

From: Carter, Charlie [carter@aisc.org]
Sent: Thursday, September 11, 2008 6:06 PM
To: Shyam Sunder
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General Comments:

1. It is easy to say that engineers should design buildings to resist collapse in an "infrequent (worst-case) fire". However, I don't see any definition of what is termed the infrequent (worst-case) fire. Fires already are infrequent events in buildings, and the worst case is impossible to define. No matter what scenario is selected as a design basis, it can be exceeded. Thus, the call to action seems emotional rather than scientific; misleading; and perhaps impossible to attain.

In all aspects of design, engineers can only reduce the probability of failure to an acceptably low level--we cannot eliminate the possibility entirely. In this regard, the prevention of a fire-induced collapse is no different than design for gravity, wind and seismic loads. A design basis is selected to ensure a sufficiently low probability, but failure

can occur if the conditions are such that load exceeds strength.
2. I think it is misleading to say that fire alone caused the collapse of WTC 7. Failures involve the interaction of multiple occurrences that combine to produce the end result. In this case, there is an innovative design, structural damage, fires, the failure of the municipal water supply and the decision to abandon the building and not fight the fires. There may be have been other factors as well.

3. The NIST report actually seems to attempt to minimize the impact of the structural damage, but there is load redistribution due to that damage that has an inevitable impact on the collapse. It also seems to be a given that we should expect fire department personnel not to fight fires based upon this one case with very special circumstances.

NIST seems to seek to establish that 7 WTC is a typical office building and makes explicit comments that the oddities of the site and design did not influence the collapse. While 7 WTC had some features that are more typical, it is not what I would call a typical office building. Typical bays in office buildings are rectangular, regular and span areas from 20 x 20 ft to 40 x 40 ft.

The tributary and influence areas on the columns at which NIST contends collapse initiated are very high in comparison even to the largest bay in this typical range. Seven WTC had tributary and influence areas that are in excess of 50% larger for columns 79, 80, and 81 than for columns in a 40 x 40-ft bay arrangement. I strongly suspect that this significant difference was a very significant factor in the collapse. The report also seems far too conclusive that the other oddities (skewed framing, transfers, cantilevers and transitions) did not contribute to the collapse. The proposed scenarios for collapse progression are not certain, just plausible.

Perhaps NIST is calling this a typical office building in comparison to the systems used in the 110-story WTC twin towers, which were called unique.

While I understand that difference, it should not be said that 7 WTC was a typical office building. It is actually more unique than it is typical, given the many structural challenges that were overcome with atypical framing and configurations.

The other structures noted in the report to have survived severe fires are more typical in nature.

4. It would be attainable and productive to suggest that fire engineering should be routine in atypical projects. Much more so than saying engineers should design for an infrequent worst-case fire.

5. There can be no absolute response to a probabilistic issue. There are many probabilities that interact in the case at hand, including: the probabilistic fire load, probability of sprinkler system failure, probability of coincident structural damage and probability of fire department response.

The real question facing the engineering profession is how often building failure without loss of life is acceptable. The answer of zero is impossible and illogical.
Answers to ENR questions:

ENR: Do you agree with the key premise of NIST's recommendations?

Carter: This premise involves an undefined target - the infrequent worst-case fire. Is this a codified design-basis fire similar to the design-basis loads we use in gravity, wind, and seismic design? If so, the provisions in AISC 360-05 Appendix 4 are already a part of the AISC Specification (and the International Building Code, by reference), and can be used to design for fire conditions. However, the term "worst-case" is a misnomer since a code-level event is not necessarily the worst case.

Alternatively, is it the intent of the NIST premise that the infrequent worst-case fire should represent any fire that could ever occur in any building? This is a tall order-- I doubt that it is even realistic to think that there is a singular fire scenario that represents the worst case for every component in a building, let alone every building and every possible use.

Thanks to hindsight, the scenario chosen today can be tuned to represent the multiple facets of the 7 WTC experience, but what about the next event with different facets? Clairvoyance is elusive.

ENR: Do you think that buildings should routinely be designed to resist thermal expansion that would trigger collapse?

Carter: I can't answer this question because I don't think NIST has established conclusively that thermal expansion triggered this collapse; nor have the proposed design criterion been identified.

I think NIST likely is correct in concluding that column buckling occurred at one or more of columns 79, 80, and 81, and this led to the progression of events that ended with total collapse. I don't think there is enough evidence to support the firmness of NIST's conclusions about what preceded column buckling. As one example, do we really think that nine intermediate stories of column 79 stood unsupported prior to buckling?

That seems impossible.

To draw such firm conclusions on a hypothesis that is plausible but not proven seems unnecessary.

ENR: Do you think there is a problem with the existing building stock that has not been designed to this load?

Thermal expansion undoubtedly occurs in any structure subjected to fire.

It also has been observed in full-scale testing of structures in fire conditions. The Cardington fire tests done in the U.K. on steel and reinforced concrete structures showed similar magnitudes of expansion in both materials, but none of the tested structures collapsed due to the expansion. I don't see that NIST's work has established thermal expansion as a cause of collapse.

ENR: NIST's new recommendation B, the 13th of its WTC investigation, says:

"NIST recommends that buildings be explicitly evaluated to ensure the adequate performance of the structural system under worst-case design fires with any active fire protection system rendered ineffective...."

"...Building owners, operators, and designers are strongly urged to act upon this recommendation. Engineers should be able to design cost-effective fixes to address any areas of concern that are identified by these evaluations...." NIST then lists "possible options for developing cost-effective fixes."

Do you agree with this recommendation?

Carter: Again, it is unclear what NIST intends with use of the phrase "worst-case." The possible options for cost-effective fixes are included with very little exploration of why they would have made a difference and how they would be cost-effective. They do not appear to be cost- effective to me.

Also, shouldn't assessment of sprinkler reliability and improvements (if necessary) be something that is listed as a potential solution? NIST states in the report that sprinklers are an acceptable solution to fire when they function.

ENR: NIST says it does not have any cost data to support its contention that engineers should be able to find "cost-effective" fixes. Please react to NIST's assumption that "fixes" could be cost-effective.

The suggestions for cost-effective fixes are speculative, and should not be included in the report. Without assessment, development and study, there is no way to know what the cost-effective solutions are. Moreover, has anyone agreed as to what fixes, if any, are needed? I don't think there is agreement on this.

ENR: Please speak out for or against the conclusions and recommendations in the report.

Carter: Absent a means to characterize what the "worst-case" fire scenario is, the recommendation in this report seems to head in a direction that will simply provide a new fire design level that is just as capable of being exceeded as the current one. The impact on the cost of design and the cost of construction are both indeterminate, because the recommendations are general and without characterization.

ENR: NIST was purposely silent about narrowing the field to any specific building type, size and whether the recommended new standard (and code) should apply to new buildings or all buildings. Please react.

Carter: Were any recommendations to be implemented, they should be applicable to all buildings, regardless of construction materials, type, size, etc. The recommendations should be limited to what is necessary and appropriate for life safety.

ENR: Do you agree with NIST that "the standards for estimating load effects of potential hazards (e.g. progressive collapse, wind) and the design of structural systems to mitigate the effects of those hazards should be improved to enhance structural integrity"?

Carter: No. I don't think we have a structural integrity problem in the buildings that naturally result from the common design and construction standards and methods used today in the U.S.